UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112-2097

26 May 2005

MEMORANDUM FOR: F/NWR – Robert Lohn

FROM: F/NWC – Usha Varanasi

SUBJECT: Low returns of spring Chinook salmon to the Columbia River in 2005

In response to your recent e-mail regarding the much lower than expected returns of spring Chinook salmon this year to the Columbia River, we evaluated a number of variables that may have affected the returns. These include the number of juveniles migrating downstream, their survival through the hydropower system, SARs, coastal ocean conditions at the time of ocean entry, several physical indices for the North Pacific Ocean, and the accuracy of jack counts and TAC predictions of returns based on the jack counts. Our conclusion based on this initial review is that no single variable, by itself, appears responsible for the observed low return. A more detailed discussion of our review, specific answers to your questions, and additional factors that might have contributed to the low return are provided below.

Question 1. In-river survival: What do we know about the numbers and survival during the in-river migration of the juveniles which resulted in this year's adult returns? I assume that this year's return migrated out in the spring of 2002 and 2003, and my general understanding is that the number of juvenile migrants during those two periods was good, and that the survival through the dams was good. Is this correct? It will be very important for us to state clearly whether or not a respectable number of these fish, as juveniles, made it through the hydro system successfully.

It would be useful to compare in-river numbers and survival for the 2002 and 2003 juvenile migrants with the juvenile migrants that resulted in the recent large runs, such as the huge returns of 2001.

Answer: Yes, the adults returning in 2005 migrated out primarily in the spring of 2003, while some migrated during the spring of 2002. The number of juvenile migrants during those two periods was good, and survival through the dams was good.

A table of data from the 2000 through 2003 juvenile outmigrations of Snake River spring/summer Chinook salmon is provided below. These include numbers of juveniles that arrived at Lower Granite Dam, survival to Bonneville Dam (same survival estimates were used for hatchery and wild fish; transported + non-transported fish were combined), percentage of the population that arrived alive below Bonneville Dam as a result of transportation, total adult returns to date from the outmigration (hatchery and wild combined) and an estimated SAR (hatchery and wild combined). We used the SIMPAS model to estimate the survival of the population as a whole that arrived alive below Bonneville Dam (which are nearly the same as a cursory estimate of the percentage of live fish arriving below Bonneville Dam based on data from survival studies).

Some points to keep in mind with respect to the table: 1) as most fish were transported, most adult returns came from transported fish; 2) on average, transported wild fish have had the same SAR as non-transported fish arriving below Bonneville Dam and transported hatchery fish had SARs approximately 25% higher than non-transported fish; and 3) the percentage of fish that return as 3-ocean fish has varied for both wild (range 12-58%, median 22%) and hatchery (range 5-38%, median 7%) fish over the last 7 years, making it difficult to predict the percentage of 3-ocean returns we would expect this year (prediction bounds are very wide).

Out-migration year	Juvenile hatchery chinook at LGR (millions)	Juvenile wild chinook at LGR (millions)	Survival to Bonneville (transport + non-transport) (%)	Percentage of survivors from transportation	Adult returns to LGR (+ estimated catch)	SAR to date (%)
2000	6.89	1.28	78	93	164,149	2.00
2001	2.03	0.48	96	~100	43,980	1.75
2002	6.35	.097	82	86	103,725	1.40*
2003	6.51	1.32	78	78	~7000	

*doesn't include adult returns in 2005

We show the total number surviving to below Bonneville Dam because that is the important number in terms of SARs. However, your question was also about estimated in-river survival during these years. For Snake River spring/summer Chinook salmon, survival from Lower Granite to Bonneville Dam was 49, 28, 58, and 53% in 2000, 2001, 2002, and 2003, respectively.

Based on these data we can say that in 2002 and 2003 the number of juveniles outmigrating and their survival to below Bonneville Dam was high, and similar to 2000. In 2001 there were fewer outmigrats and they had a lower in-river survival.

Question 2. Jack counts and abundance estimates: A brief review of the accuracy of the jack counts (Were the jacks correct and correctly attributed to the appropriate brood years?) would be helpful just to make sure the data relied upon in the predictions was accurate.

Answer: Yes. We believe that fish counters make relatively accurate counts of jacks on an annual basis.

In addition, a review of the methodology used to extrapolate from jack counts to a predicted run size would be valuable. Was the process done correctly? Should we be looking at some way to improve it?

Answer: We have not reviewed the methods TAC used. We independently derived an estimate of returns to the Snake River in 2005, and found the discrepancy between our prediction and the actual count, to date, was similar to the discrepancy between the TAC estimate to the mouth of the Columbia River and the actual Bonneville Dam count.

We have talked with Peter Dygert about the methodology used by TAC to make adult predictions to the mouth of the Columbia River, but have not actually seen it directly nor have we reviewed it in the past. It appears that TAC uses a regression of 3-year old fish (jacks) to 4-year old (2-ocean) fish, and a regression of 4-year old to 5-year old fish for several river basins, and then adds the results together.

In the absence of TAC data and detailed information on their methods, we used our extensive Snake River data base to construct an analysis with hatchery fish to estimate total

returns from the 2003 outmigration (it produced last year's jacks). Though TAC's methods predicted the 2005 run of spring Chinook salmon to the mouth of the Columbia River, we would expect the trend in hatchery fish in the Snake River basin to mirror the overall TAC estimate, as it represents a large proportion of the Columbia River run each year. We conducted a simple linear regression on 44 years of Snake River hatchery jacks compared to combined 2-and 3-ocean returns. Based on more than 6,300 hatchery jacks returning in 2004, we predicted a mean total return of approximately 80,000, with prediction bounds of approximately 64,000 to 94,000 fish (Figure 1).

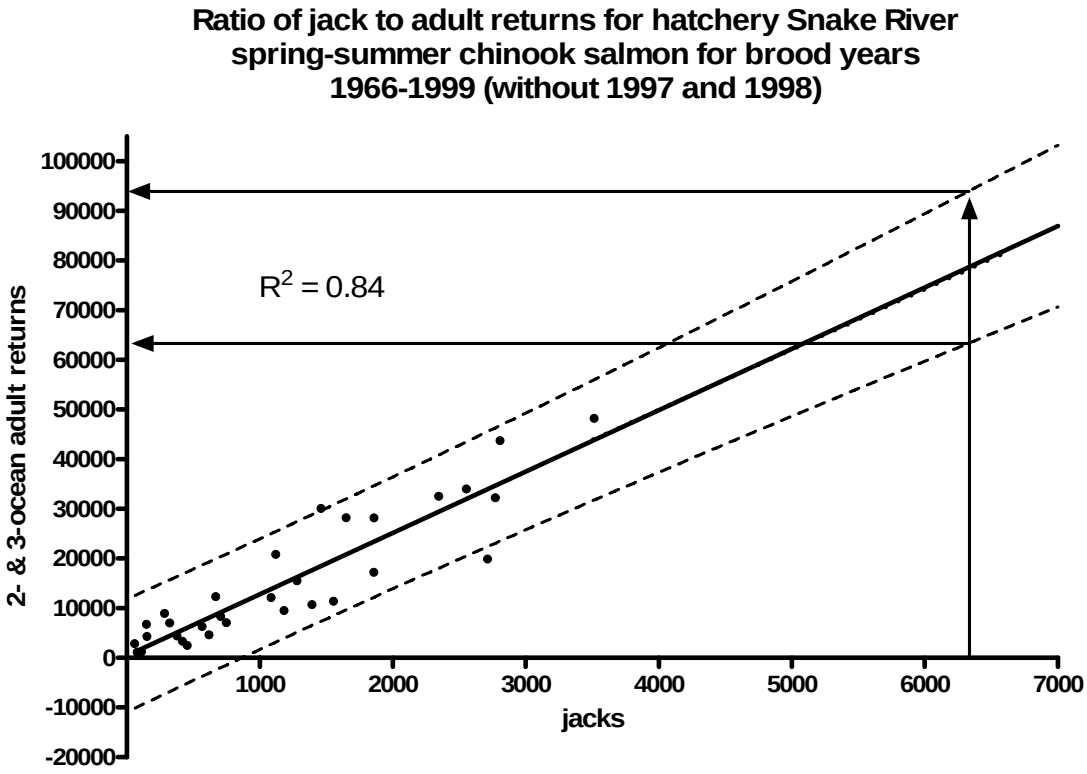

Figure 1. Linear regression of total 2- and 3-ocean adult returns vs. jack returns for Snake River hatchery Chinook salmon 1966-1999 (excluding the high returns from the 1997 and 1998 brood years), with the range of estimated total adult returns (2- and 3-ocean fish) within the 95% prediction interval for fish from brood year 2001 (outmigration 2003, which produced an estimated 6300 jacks to the Snake River in 2004).

This total return will include adult fish returning in 2006 as well as 2005. However, to date only 17,876 fish (not expanded for any downstream catch and includes wild fish) have passed Ice Harbor Dam and some of these were 3-ocean fish from the 2002 outmigration. The discrepancy between our prediction of returns to the Snake River and actual counts are similar to the discrepancy in the TAC estimate to the mouth of the Columbia River and the Bonneville Dam count. We do not know if the TAC estimate included prediction bounds.

Question 3. Ocean conditions and interceptions: My understanding is that, while we have from time to time marked a number of these fish, we have little or no data on where they go in the ocean. This is unlike the Willamette and Lower Columbia Spring Chinook, where we have a number of interceptions documented. About all we seem to be able to say is that the Upper Columbia fish don't seem to go where the Lower Columbia fish go, or they would have been noted. At any rate, any information you can provide about potential ocean conditions effects would be useful, and if you have any thoughts on further, future research, they would welcome as well.

Answer: Conditions in the coastal ocean environment were less favorable for salmon in 2003 than in recent years. Yes, you are correct, we do not know where the Upper Columbia River fish feed in the ocean because for the most part they are not intercepted by the fisheries.

We conduct extensive sampling in our coastal waters, and during 2003, the ocean off Oregon and Washington was experiencing a 'prolonged but weak El Nino' event. This was reflected, in part, by the Pacific Decadel Oscillation Index (PDO) switching from a reading that favors salmon production in the Pacific Northwest (from 1999-2002) to a reading that is less favorable for salmon. In addition, we monitor two additional biological indices of the coastal environment. The northern copepod index is a measure of the amount of copepods associated with cooler sub-Artic marine habitats, and during 2003 it switched indicating that copepod numbers were lower than normal. In addition, our index of the piscine predator abundance off the mouth of the Columbia River in 2003 was higher than we have seen since 1999. These indices collectively pointed to a coastal marine environment for juvenile salmon that was less favorable than the previous 4 to 5 years (1998-2002). Although lower, the indices did not indicate to us that 2003 was an extremely anomalous year compared to other years. Thus, we did not expect

to see the extremely low level of returns that have occurred thus far in 2005.

Smolt-to-adult survival rates are largely set during the first year at sea; primarily during the first summer and winter of ocean life. We have not observed in the past a large mortality of fish once they have spent one year in the ocean. As a matter of fact, nearly all modeling efforts to estimate life-cycle productivity of salmon, (using Ricker, Beverton-Holt, or Matrix models) have used a presumption of 80% survival between adult age classes. However, this does not preclude the possibility of significant mortality occurring later in their ocean existence by some unexplored and unexplained variable. We do not currently evaluate ocean conditions in the area occupied by subadult and adult spring Chinook salmon, largely because we do not know what area of the ocean they inhabit during this life stage. It remains possible that the low returns this year resulted from significant mortality in an area of the ocean that we are currently not evaluating.

I note that some of the Northern Alaska runs, including the Yukon and adjacent rivers, are down dramatically. Does this give us a hint that the Upper Columbia fish are feeding in the same location?

Answer: We do not know where the Upper Columbia River fish feed in the ocean. It is premature to speculate that they are located in areas similar to Northern Alaska runs. However, we are discussing the status of spring Chinook runs in Alaska with colleagues at the Auk Bay laboratory to determine whether they have the same trends as Columbia River runs.

Also, Jim Balsiger happened to mention that the bycatch of salmon in the pollock fishery was especially high this year. I know they are working on categorizing the salmon. Could you check with Alaska to see what effect the interceptions may be having on our stocks?

Answer: We reviewed a 20-year data set of CWT recoveries of Chinook salmon from bycatches in Gulf of Alaska fisheries. Of 210 CWT-tagged Chinook salmon recovered from the Columbia River basin, only 10 had an interior Columbia River basin spring Chinook lineage, and most were caught as juveniles in their first summer at sea; only 1 was an adult. In contrast, for the remaining 200 Columbia River basin fish from other genetic lineages all but 14 were captured after their first winter at sea. Bering Sea CWT recoveries contained no interior Columbia

River basin spring Chinook salmon. These data together indicate that upper Columbia River spring Chinook salmon adults are not caught in the ocean.

Question 4. If, the facts do indeed point to ocean conditions, I would like to talk with you about doing a collaborative effort with other parts of NOAA to see what more we can say about such conditions, both historically and in the future. I think there would be strong support at the VADM level about such an effort, which would demonstrate the power of matrixed capability and showcase NOA's strengths.

Answer: Yes, we are very interested in discussing a broader collaboration with you.

Variations in ocean productivity have a large influence on recruitment and return rates, as discussed above. In general, this contribution has largely been overlooked by regional salmon managers. We have been conducting extensive sampling of the coastal Oregon and Washington waters measuring the underlying productivity to understand how ocean conditions affect resources. We have continuous (biweekly) data as far back as ten years for some of our sample lines. Recognizing the importance of these data, this past year we developed a "Summit to the Sea" climate and ecosystems initiative that uses salmon as integrators to look at the effects of climate across freshwater, migration corridor, and ocean ecosystems. It presents the start of an integrated "One NOAA" approach to the effects of climate and climate variability on the resources that we manage by collaborating with several other line offices. Secondly, we are working closely with the NMFS Office of Science and Technology on a proposal under the NOAA Climate Goal for a demonstration project along our coast where we develop means to incorporate climate variability and ecosystem observations into the stock assessment process. In this project krill (euphausiids), sardines, and hake responses would be targeted. We would very much like to brief you on both of these initiatives and discuss ways in which we could collaborate with others within NOAA and our academic partners to meet both your needs and those of the Pacific Fishery Management Council. As indicated above, we also need to have a better understanding of ocean conditions beyond those found off the Pacific coast. Spring Chinook salmon are only found on the coasts during their early entry to seawater, and the unexpectedly low returns this year suggest adverse conditions in the ocean beyond areas where we have measurements. Some researchers have used broad indices,

such as the Pacific Decadal Oscillation and location of the Aleutian Low, to link changes in salmon stock productivity to broad patterns in ocean changes. We see a need to have a better resolution on where and when physical factors change in smaller areas of the ocean. Potentially, we could work with OAR and NESDIS to obtain this information.

In summary, no single variable or factor that we examined appears responsible for the observed low return. Probably a combination of factors played a role. These could include factors discussed here as well as additional factors, and we pose several of them, as follows:

a. Fish from the 2003 outmigration will return at the high end (or higher) of the historical distribution of percentage of 3-ocean fish seen in past years. They may not have returned as 2-ocean fish this year because of poor growth during their second year in the ocean and thus a higher proportion than normal have stayed another year in the ocean to grow before maturation. However, the return will not reach our lower prediction bound for Snake River fish unless 60-70% of the hatchery fish return as 3-ocean fish, and this percentage would far exceed any historic values.

b. Marine mammals in the lower Columbia River have had a greater than average affect on the upriver run in 2005. We do not know if sea lion predation has changed, but we have seen a higher level of marine mammal scars on spring Chinook salmon sampled at Lower Granite Dam this year. These scars are on fish that survived to reach Lower Granite Dam, and our staff believes most are caused by harbor seals, based on sizes of teeth marks and the assumption that sea lions are successful predators and do not leave scarred fish.

Year	Descaled (%)	Flesh wound (%)
2005	28.1	13.9
2002	11.3	8.8
2001	12.7	8.2
2000	14.3	4.5
1999	14.8	6.5
1998	19.7	8.9
1997	9.9	5.9
1996	10.4	6.0

1995	12.4	5.4
1994	14.8	10.7
1993	12.5	5.8

c. Ocean conditions (as noted above) may have affected adult fish that remained after their first year in the ocean. We did evaluate 5 ocean-climate indices for the North Pacific Ocean (Aleutian Low Pressure, El Niño/Southern Oscillation, North Pacific, Pacific Decadal Oscillation, and Northern Oscillation Index). These are indices that measure various couplings between the atmosphere and North Pacific Ocean that drive productivity in the North Pacific marine ecosystem. Based on these indices, marine survival conditions were generally poor through the mid-1990s with subsequently low adult returns. In 1998-99 the NE Pacific underwent a regime shift toward conditions more favorable to Columbia River salmon; in 2001, returns of wild Snake River spring/summer Chinook exceeded the previous 5 years by nearly an order of magnitude and these were largely 2-ocean fish that went to sea in 1999. The trend of high returns continued for another two years (adults going to sea through 2001). However, beginning in 2002, we observed a switch in 3 of the indicators toward a negative direction for salmon, with one (Alaskan Low Pressure) being the second largest value observed in the past 45 years. Later in 2002-2003, a fourth index switched direction toward the less favorable state. Therefore, these conditions may have lead to less favorable returns of Columbia River stocks, at least compared to those of the previous 3 years.

d. Recently we have been conducting surveys of predators along our coastline to evaluate their role in juvenile salmon survival. In March of the past three years as part of this work, we observed killer whales feeding in the Columbia River plume near the mouth. We believe that the Columbia River plume may serve as part of the winter feeding grounds for killer whales. We plan to continue these surveys to build a longer time series to better understand the sightings and variability among years and their possible feeding on salmon during this period.

e. Salmon may be more sensitive to changes in physical changes in the ocean than suggested by our ocean indices. This may entail developing additional biological metrics of ocean

conditions that reflect more accurately the biological response to changing ocean conditions.

f. The forecast by TAC was much too high, as was a simple estimate we derived from our Snake River data base. Even if TAC had provided prediction bounds, we believe they would not have correctly forecasted this year's return. We could work with TAC, if you would like, to review the methods they used. But we think we should only do so as part of TAC's own review, not an independent review, and only after this was carefully coordinated with TAC through Peter Dygert.

cc: F/NWC – Stein
F/NWC – Iwamoto
F/NWC3 - Ferguson
F/NWC3 – Williams
F/NWC3 – Casillas
F/NWR - Toole